



# Nucleons and nuclei **for** neutrino physics

TF11 2nd hour meeting - 30 July 2020

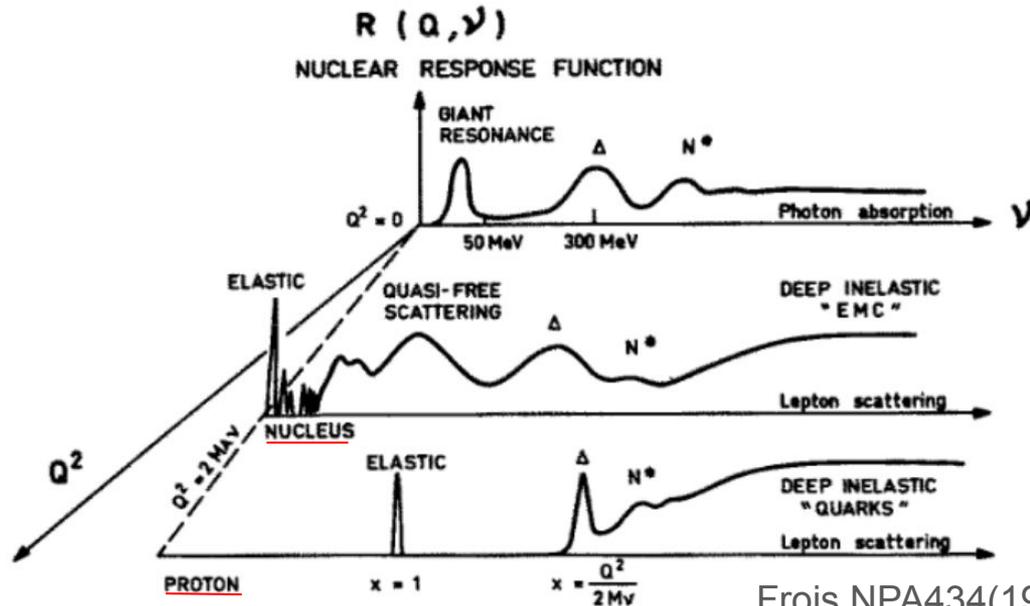
Saori Pastore for TF11/NF08  
Washington University in St Louis

# Nucleons and Nuclei for Neutrinos Physics & Fundamental Symmetries

Nucleons and nuclei are used for **precision tests** of the standard model and in searches for **physics beyond the standard model**.

An accurate understandings of **nucleons** and **nuclei** structure and dynamics in **wide range of energy and momentum transfer** is required to disentangle new physics from standard nucleon and nuclear physics effects.

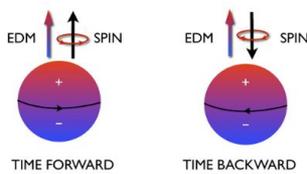
# e-Nucleon & Nucleus Scattering Cross Section



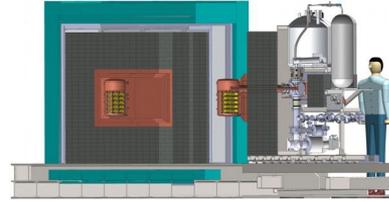
Energy and tri-momentum transferred ( $\omega, q$ ); Energy and four-momentum transferred ( $\omega = \nu, Q^2 = q^2 - \omega^2$ )

Current and planned experimental programs rely on theoretical calculations at different kinematics

Ground States'  
Electroweak Moments,  
Form Factors, Radii



Neutrinoless Double  
Beta Decay,  
Muon-Capture



Accelerator Neutrino  
Experiments,  
Lepton-Nucleus XSecs

$\omega \sim 0$  MeV

$\omega \sim \text{few MeVs}$   
 $q \sim 0$  MeV

$\omega \sim \text{few MeVs}$   
 $q \sim 10^2$  MeV

$\omega \sim \text{tens of MeVs}$

$\omega \sim 10^2$  MeV  
and more



FRIB



Electromagnetic  
Decay, Beta Decay,  
Double Beta Decay &  
inverse processes



JINA-CEE

Nuclear Rates for  
Astrophysics,  
Reactor Neutrinos



# Strategy

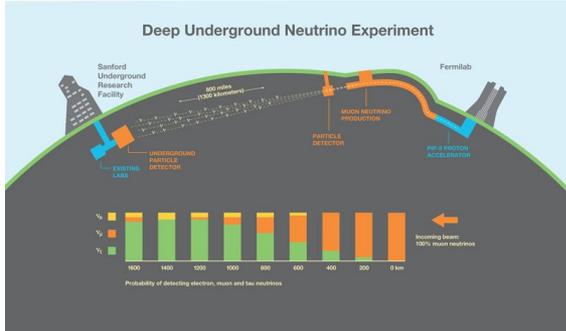
## **Validate Physics Models against available data for strong and electroweak observables**

- Energy Spectra, Electromagnetic Form Factors, Electromagnetic Moments, ...
- Electromagnetic and Beta decay rates, ...
- Muon Capture Rates, ...
- Electron-Nucleon and Nucleus Scattering Cross Sections, ...

## **Use attained information to make (accurate) predictions for BSM searches and precision tests**

- EDMs, BSM searches with beta decay, ...
- Neutrinoless double beta decay, ...
- Neutrino-Nucleon and Nucleus Scattering Cross Sections, ...
- DM-matter interactions, ...
- Neutrino propagation in dense matter, ...
- ...

# Nucleon and Nuclei for Accelerator Neutrinos

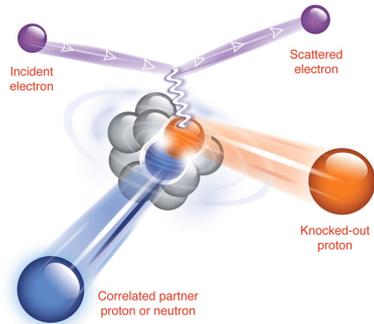


Nuclei are the active material of neutrino detectors

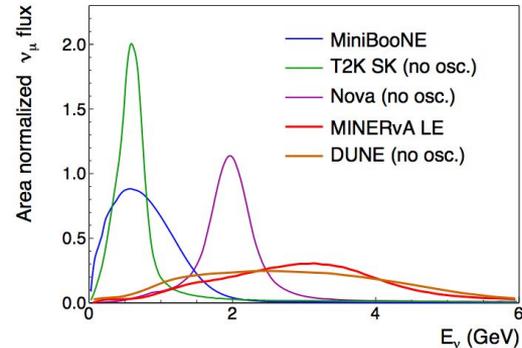
Data interpretation relies on theoretical calculations of neutrino-nucleon and nucleus interactions

Wide energy range spanned

Collaborative effort NFXX+TFXX+... necessary for progress

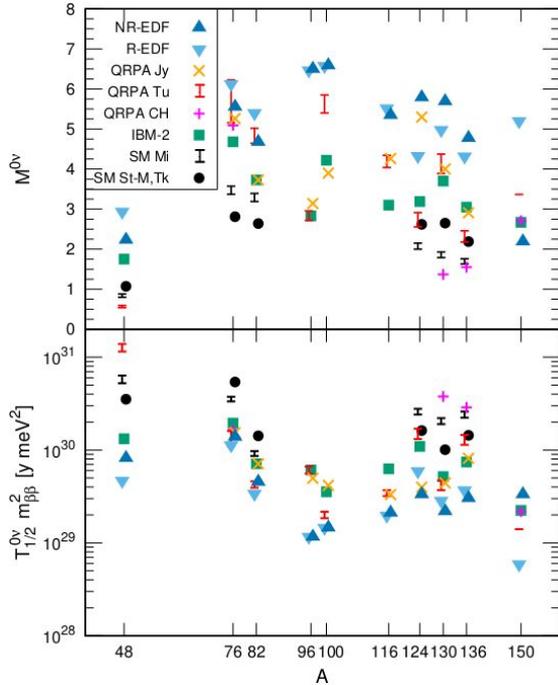


Subedi et al. Science320(2008)1475



Cern Courier (2017)

# Neutrinoless Double Beta Decay

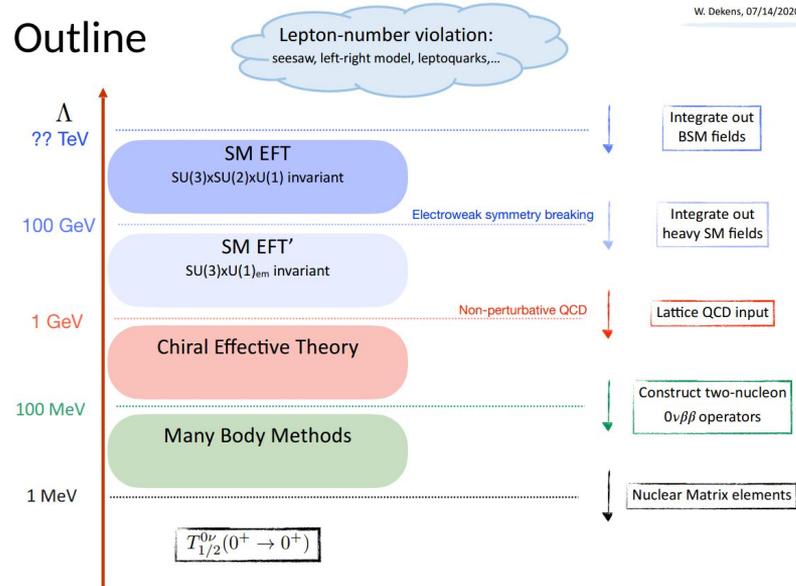


Engel & Menéndez  
Rep.Progr.Phys80(2017)046301

Calculated nuclear matrix elements for neutrinoless double beta decay are required to extract neutrino parameters

Collaborative effort NFXX+TFXX+CompFXX+... necessary for progress

## Outline



Dekens - INT talk July 2020

# NF08/TF11

- We had a preliminary joint meeting with NF01-NF06

**NF01: Neutrino Oscillations**

**NF02: Sterile Neutrinos**

**NF03: BSM**

**NF04: Neutrinos from natural sources**

**NF05: Neutrino properties**

**NF06: Neutrino Interaction Cross Sections**

- We would like to call for more of these meetings and welcome TFX delegations to participate